M.P.D. File

CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

OTTAWA

MINES BRANCH INVESTIGATION REPORT IR 63-103

PILOT PLANT JIG TESTS ON IRON ORE FROM THE SNAKE RIVER AREA, YUKON TERRITORY, FOR CREST EXPLORATION LIMITED

by

P. D. R. MALTBY

MINERAL PROCESSING DIVISION

COPY NO. 12

OCTOBER 28, 1963

Industrial Confidential

Mines Branch Investigation Report IR 63-103

PILOT PLANT JIG TESTS ON IRON ORE FROM THE SNAKE RIVER AREA, YUKON TERRITORY, FOR CREST EXPLORATION LIMITED

by

P. D. R. Maltby*

SUMMARY OF RESULTS

Jig tests were done, on 52 tons of a shipment made up of three sections of ore, using a Wemco Remer pilot plant jig. Tests were done on ore crushed either to 3 m or 4 m. The better results were obtained on the ore crushed to 4 m. It appeared that the ore could be concentrated by jigging in one operation at feed rates up to 2 tons/hr with the recirculation of a ground middling product to the feed end of the jig.

Concentrates grading better than 60% Fe were readily attainable. Phosphorus rejection varied from section to section, from an average of 0.24% P in "A" section concentrates to 0.09% P in "C" section concentrates. It was found that iron recoveries could be made over 60% but only at the expense of concentrate grade.

A total of 19.7 tons of jig concentrates were produced and calculated to contain 61.9% Fe with 0.13% P and about 8% SiO_2. Overall iron recovery was 60.7% with a ratio of concentration from the crude feed of 2.64:1.

---

*Senior Scientific Officer, Mineral Processing Division, Mines Branch, Department of Mines and Technical Surveys, Ottawa, Canada.

CONTENTS

TABLES

INTRODUCTION

Laboratory jigging operations had been first done on small samples of Crest ore using a Denver mineral jig. The results of these tests have been reported* and were encouraging enough to warrant larger scale pilot plant tests using a pilot plant model of the Wemco Remer jig, a proven production jig. Accordingly about 55 tons of iron ore were flown out of the Yukon and arrived at the Mines Branch on September 9, 1963. The Company wished the ore to be treated in three sections, designated A, B and C. The reason for doing this was due to the varying phosphorus content of the ore.

Object of Investigation

The object of the investigation was to determine if the pilot plant jig could produce concentrates similar in quality to those produced using the laboratory jig. It was desired to find the best method of jigging the ore with regard to feed size, jig settings, and flowsheet. It was desired also to find out what effect concentrate grade had on iron recovery.

Ore Sample

A total of 58 tons of ore was received at the Mines Branch on September 9, 1963 in 75 lb bags, from Crest Exploration Limited, 329A - 6th Ave., S.W., Calgary, Alberta. Approximately 6 tons of material was not treated since it was in unmarked bags or was waste rock that had been included in the shipment. The remaining 52 tons were made up of approximately 8 tons of "A" ore (a section from 65 ft to 113 ft), 22 tons of "B" ore (a section from 113 ft to 240 ft), and 22 tons of "C" ore (a section from 240 ft to 406 ft excluding a section of waste from 340 ft to 381 ft). The size of the ore lumps ranged from fines to lumps of 8 in. diameter or more.

Characteristics of the Ore

Mineralogical work had been completed on the ore before the large scale shipment arrived, and a report had been distributed to the Company.

Chemical Analysis of Samples

The majority of the analyses shown in this investigation report was done by the Analytical Chemistry Sub-Division, Mineral Sciences Division, Mines Branch. All phosphorus analyses were done by taking the apatite into solution with acid. However, these analyses were checked for total phosphorus using the total decomposition method. In most cases the two analyses were in fairly close agreement, especially on concentrates.

Other iron assays were done by the writer and Mr. K. Culver of Crest Exploration using the "Lerch" method for iron determinations by the stannous chloride - potassium dichromate procedure.

---

*Mines Branch Investigation Report IR 63-94.

OUTLINE OF INVESTIGATION

Most of the jig tests were done with the co-operation of Mr. A. Dixon, a Wemco test engineer, and Mr. K. Culver of Crest Exploration Limited.

The laboratory jig tests had been done on minus 6 m feed, due mainly to the small size of the jig and its inability to handle a larger size of feed. It was decided to commence jigging in the pilot plant on minus 4 m feed as good liberation of the hematite-rich bands from the jasper-rich bands seemed to be achieved at this size, and 4 m material made good jig feed.

It was decided to treat "A" section first. It was all crushed to minus 4 m using a Hazemag impact crusher. The crushed ore was fed to the jig and concentrates collected. The tailing product from this first run was then rejigged to recover additional concentrate.

Part of the "B" section was treated in the same way. Tests were also run on ore from "B" section crushed to 3 m. At this size there was a large amount of "locked" particles which meant that recovery was low. The tailing products at 3 m were rejigged but the additional recovery was still poor. After all the original ore had been treated, various 3 m products were crushed to 4 m and rejigged to recover additional iron at a good grade.

In the treatment of "C" section, all of the ore was ground to 4 m and various treatment schemes tried. It was found that reasonable recovery and grade could be made in one stage of jigging by regrinding the gate concentrate in a rod mill before returning it to the head end of the jig.

After the initial startup of each day's run, composite samples were taken every 15 minutes throughout the run. Each sample was cut for 5 seconds at a time. In most of the tests the ore was fed to the jig by means of a classifier. The overflow was sampled and rejected to tailing. No. 1 and 2 hutch products were combined, and pumped to a holding cone. The cone overflow was sampled and rejected to tailing.

Description of Jig

The jig used in the tests was a Wemco Remer pilot jig which has a 1 ft wide x 3 ft long bed. The jig combines a long and a short stroke into a compound pulsation which permits use of a larger jigging area, with increased jigging efficiency. The long stroke at low frequency provides the conventional jigging movement while the short high frequency stroke activates the entire bed mass, giving uniform permeability. For the most efficient separation on a given ore several variables on the jig may be adjusted. These include the size of ragging, length of stroke, slope of bed, stroke speed, depth of bed, and degree of suction at each hutch.

The method of operation of the jig is as follows. Feed from some type of feeder drops into the feed box at the high side of the bed. The jig has 4 hutches numbering from the feed end. Concentrates are drawn down into

the hutches as the feed works along the bed towards the tailing weir. Hutch products discharge through spigots into drums. At the tailing end of the bed, a gate concentrate is collected while a tailing product overflows a weir.

It is stated that the pilot plant jig will prove up a complete plant operation prior to installation of full scale commercial-size equipment.

RESULTS

Jigging Results on "A" Section

Jigging tests were started on September 12, 1963 on ore from "A" section crushed to minus 4 m using a Hazemag crusher in closed circuit with a vibrating screen. The results of a screen analysis on the crushed feed are shown in Table 1.

TABLE 1

Jig Feed Crushed to 4 m

Size	Weight %	Analysis % Fe	Distn % Fe
+6 m	11.3	42.07	11.4
-6 +8 m	22.6	41.10	22.3
-8 +10 m	18.0	46.42	20.0
-10 +14 m	11.1	41.59	11.1
-14 +20 m	9.3	41.10	9.2
-20 +28 m	6.0	40.54	5.8
-28 +35 m	5.2	40.30	5.0
-35 +48 m	3.6	39.25	3.4
-48 +65 m	2.9	39.33	2.7
-65 +100 m	2.5	38.04	2.3
-100	7.5	37.88	6.8
Total	100.0	41.71	100.0

Tests were started using 3/8 in. diameter ragging in all hutches and a 1/4 in. stroke. Jig slope remained unchanged in all the tests at 1 in. per ft base slope. Under these conditions, at a feed rate of about 1,500 lb/hr, an overall concentrate was produced containing 58.6% of the iron at a grade of 60.8% Fe. Ratio of concentration was 2.5:1. In subsequent testing the stroke was increased to 3/8 in. The overall concentrate grade dropped to 58.6% Fe with a recovery of 49.9% of the iron. Feed rate was 1,200 lb/hr. About 2 tons were treated in this test. On a feed of 3 tons, a test was run at a feed rate of 1200 lb/hr with the results shown in Table 2. The ragging in all the hutches, apart from No. 1, was changed to 1/2 in.

TABLE 2

Results of Jigging Crude Feed at 3/8 in. Stroke

	Weight %	Analysis %*		Distn %	
		Fe	P	Fe	P
No. 1 Hutch	13.0	48.52	0.41	15.8	14.3
No. 2 Hutch	22.6	59.96	0.24	33.9	14.5
No. 3 Hutch	8.0	65.05	0.16	13.0	3.4
No. 4 Hutch	0.9	64.87	0.20	1.5	0.5
Gate concentrate	1.1	28.35	0.58	0.8	1.7
Tailing	54.4	25.72	0.45	35.0	65.6
Calc feed	100.0	39.9	0.37	100.0	100.0

*From Internal Report MS-AC 63-1193.

A screen analysis was done on the tailing product with the results shown in Table 3.

TABLE 3

Screen Analysis of Jig Tailing

Size	Weight %	Analysis % Fe	Distn % Fe
+6 m	4.4	14.27	2.5
-6 +8 m	12.5	14.99	7.5
-8 +10 m	14.3	16.52	9.5
-10 +14 m	9.5	19.83	7.6
-14 +20 m	9.9	23.94	9.5
-20 +28 m	8.3	28.69	9.5
-28 +35 m	8.9	32.64	11.6
-35 +48 m	6.5	33.29	8.7
-48 m	25.7	32.56	33.6
Total	100.0	24.9	100.0

Finally a test was done using 1/4 in. stroke with 3/8 in. ragging in No. 1 and No. 2 Hutches, and 1/2 in. ragging in No. 3 and 4 Hutches. Feed rate was 2000 lb/hr. On the combined hutch concentrates and gate concentrates, the iron recovery was 52.8% at a grade of 58.1% Fe.

After all the 4 m crude feed from "A" section had been jigged, the tailing products were combined and rejigged using 3/8 in. ragging throughout and 1/4 in. stroke. The feed rate was 1,500 lb/hr. The results are shown in Table 4.

TABLE 4

Rejigging of Combined Tailing Products

Product	Weight %	Weight % as crude feed	Analysis %* Fe	Distn % Fe	Distn % as crude feed Fe
No. 1 Hutch	3.4	2.2	58.18	6.9	3.3
No. 2 Hutch	2.0	1.3	55.89	3.9	1.8
No. 3 Hutch	4.6	3.0	54.89	8.7	4.1
No. 4 Hutch	8.6	5.6	53.29	15.9	7.5
Gate concentrate	2.1	1.3	39.72	2.9	1.4
Tailing	79.3	51.5	22.46	61.7	29.1
Feed	100.0	64.9	28.84	100.0	47.2

*From Internal Report MS-AC-63-1195.

Combining the concentrates obtained from rejigging the tailing with the concentrates from the crude ore gave an overall iron recovery of 69.5% at a grade of 57.3% Fe. Ratio of concentration was 2.12:1.

In all the tests full suction was used on No. 2 and 3 Hutches with some water on No. 1 Hutch. The No. 4 Hutch and gate concentrate products were controlled mainly by the water added to the hutch. The stroke speed throughout was 155 rpm.

Further Jig Tests on "A" Section

Due to improvements in technique as the test programme developed on the other sections, it was decided to re-treat "A" section under these conditions. The main addition to the circuit was a 20 in. x 30 in. rod mill with a 3 hp motor which ground the gate concentrate. After grinding, the gate concentrate was returned to the jig with the crude ore and a steady circulating load was maintained. The object of this procedure was to produce as high a grade as possible on the hutch products with maximum recovery and no re-treatment of the tailing products.

Under the supervision of the Wemco engineer, the check boards above the jig base plate were cut in order to correspond more closely to the commercial-size jigs. It was also thought that the reduction in bed depth would give beneficial results. The check boards, which hold the ragging in place, were cut by 1 in. in height along the jig bed. The tailing weir was also cut in height by 1 in. and, adjustable bars made so that the bed could be raised or lowered as required. It was not possible to determine the effect of this for the remainder of the test.

All the concentrates from the previous jig tests were combined together with the tailing products and thoroughly mixed. The jig was run

with a stroke of 3/8 in. at 155 rpm. The ragging on No. 1 and 4 Hutches was 3/8 in., and 1/2 in. on No. 2 and 3 Hutches. The rod charge in the rod mill was 500 lb. Crude feed rate 3,000 lb/hr. The gate concentrate return rate was 800 lb/hr. In order to obtain a clearer picture of the hutch product grades, the minus 65 m fines from No. 1, 2 and 3 Hutches were screened out from the individual samples and combined for a separate assay. The test lasted 2 days. The results from each day were combined and are shown in Table 5.

TABLE 5

Results of Jigging Recombined Products

Product	Weight %	Analysis %*			Distn %
		Fe	P	SiO_2	Fe
No. 1 Hutch	3.3	59.41	0.21	11.42	5.3
No. 2 Hutch	6.3	64.97	0.19	4.80	11.1
No. 3 Hutch	18.6	60.56	0.25	9.26	30.5
No. 4 Hutch	5.6	57.42	0.28	13.18	8.7
-65 m Hutch product	0.9	54.31			1.3
Gate conc	28.0	38.91			-
R.M. discharge	-	38.12			-
Cone o'flow	0.1	38.98			0.1
Class o'flow	1.0	33.88			1.0
Tailing	64.2	24.15			42.0
Calc feed	100.0	36.90			100.0
Assay feed		36.63	0.30		

*From Internal Report MS-AC-63-1269.

The results of screen tests are shown in Table 6.

In Table 5 the iron and phosphorus head analyses were lower than the original feed sample from "A" section. Slightly more jig tailing was recombined with the original concentrates than required, which would account for the lower iron analysis. Some of the original "A" section tailing had become mixed with tailing from the other sections which would account for the lower phosphorus feed analysis.

TABLE 6

Results of Screen Tests on Jig Products

Size	Gate concentrate Wt. %	Rod mill discharge Wt. %	Tailing		
			% Weight	% Fe	Distn % Fe
+6 m	23.9	0.8	5.4	13.30	3.0
-6 +8 m	34.8	6.1	15.1	18.30	11.4
-8 +10 m	21.7	14.7	17.4	18.57	13.3
-10 +14 m	10.3	16.1	13.6	22.31	12.5
-14 +20 m	5.8	16.6	13.8	25.98	14.8
-20 +28 m	1.8	11.9	10.6	29.94	13.1
-28 +35 m	1.0	9.2	8.4	32.21	11.2
-35 +48 m	0.4	6.3	5.8	33.21	7.9
-48 m	0.3	18.3	9.9	31.43	12.8
Total	100.0	100.0	100.0	24.2	100.0

Jigging Results on "B" Section

Tests on 4 m Feed

Jigging tests on the crude ore from "B" section were started on feed crushed to minus 4 m. A screen test was done on the crushed ore which gave practically the same structure as shown in Table 1 on "A" section ore crushed to the same size. The first test was run at a feed rate of 1,500 lb/hr and a 1/4 in. stroke. The size of ragging was 3/8 in. on No. 1 and 2 Hutches and 1/2 in. on No. 3 and 4 Hutches. The results are shown in Table 7. About 4 tons of ore were treated in this test.

TABLE 7

Results of Jigging Minus 4 m Ore

Product	Weight %	Analysis %*			Distn %	
		Fe	P	Tot P	Fe	P
No. 1 Hutch	1.4	61.28	0.11	0.12	2.1	0.5
No. 2 Hutch	0.6	62.77	0.14		0.9	0.3
No. 3 Hutch	1.3	64.07	0.12		2.0	0.5
No. 4 Hutch	5.2	64.43	0.12		8.2	2.1
-65 m Hutch product	3.7	45.67	0.33		4.1	4.1
Cone o'flow	1.1	40.72	0.34		1.1	1.2
Gate concentrate	13.8	61.48	0.13	0.13	20.8	6.0
Tailing	72.9	34.09	0.35		60.8	85.3
Calc feed	100.0	40.9	0.30		100.0	100.0

*From Internal Report MS-AC-63-1198.

The tailing products were combined and rejigged at two different feed rates using a 3/8 in. stroke and the size of ragging unchanged. At a feed rate of 3,600 lb/hr, the additional recovery of iron was 19.2% of the original feed at a grade of 55.5% Fe and 0.22% P. Overall ratio of concentration for the combined concentrates from both jigging operations was 2.81:1.

In another test on the combined tailing products the stroke speed was raised to 160 rpm from 150 rpm and the feed rate lowered to 2,000 lb/hr. The results are shown in Table 8.

TABLE 8

Results of Rejigging Combined Tailing Products

Product	Weight %	Weight % of crude feed	Analysis %*		Distn % Fe	Distn % as crude feed Fe
			Fe	P		
No. 1 Hutch	3.7	2.7	60.28	0.14	6.7	4.1
No. 2 Hutch	3.1	2.3	64.11	0.10	6.0	3.6
No. 3 Hutch	12.0	8.7	57.37	0.16	20.7	12.6
No. 4 Hutch	13.6	9.9	47.15	0.30	19.3	11.7
-65 m Hutch product	5.0	3.6	36.97		5.6	3.4
Gate conc	2.0	1.5	40.48		2.4	1.5
Tailing	60.6	44.2	21.52		39.3	23.9
Feed	-	-	33.0		-	-
Calc feed	100.0	72.9	33.2		100.0	60.8

*From Internal Report MS-AC-63-1215.

Tests on 3 m Feed

It was decided to find out what results could be obtained by jigging ore crushed to 3 m. Accordingly about 18 tons were crushed to 3 m, still using the Hazemag crusher in closed circuit with a vibrating 3 m screen. Several test runs were made in which jig variables were changed to try to improve iron grades and recoveries. Concentrate grades over 60% Fe could be made; but in no case could the tailing product be lowered below 30% Fe which meant that iron recovery was never better than 50%. The best results were obtained with 3/8 in. stroke at a speed of 150 rpm. Ragging size was 1/2 in. except for 3/8 in. ragging in No. 1 Hutch. Feed rate was 4,000 lb/hr. Full suction was used on the first three hutches. The results are shown in Table 9.

TABLE 9

Results of Jigging Minus 3 m Crude Feed

Product	Weight %	Analysis %*			Distn %
		Fe	P**	SiO_2**	Fe
No. 1 Hutch	1.6	61.04	0.11	8.12	2.4
No. 2 Hutch	1.1	64.11	0.09	5.52	1.8
No. 3 Hutch	1.1	65.43	0.09	5.56	1.8
No. 4 Hutch	4.7	64.41	0.09	-	7.6
-65 m Hutch product	2.8	44.45			3.1
Gate concentrate	22.9	58.66	0.15	11.30	33.5
Cone o'flow	0.4	40.30			0.4
Tailing	65.4	30.24			49.4
Assay feed	-	39.66			-
Calc feed	100.0	40.1			100.0

*From Internal Report MS-AC-63-1206.

**The phosphorus and silica analyses were made on samples of about the same grade taken from other tests on the same material.

In order to improve recovery, the tailing products from all the tests were combined and rejigged with the same settings as above. Feed rate averaged about 3,000 lb/hr. The results are shown in Table 10.

TABLE 10

Results of Jigging Combined Tailing Products

Product	Weight %	Weight % crude feed	Analysis %* Fe	Analysis %* P	Distn % Fe	Distn % of crude feed Fe
No. 1 Hutch	0.9	0.6	61.92	0.11	1.9	0.9
No. 2 Hutch	0.6	0.4	65.75	0.07	1.3	0.6
No. 3 Hutch	1.1	0.7	62.08	0.17	2.4	1.2
No. 4 Hutch	4.4	2.9	55.09	0.21	8.2	4.1
-65 m Hutch product	0.5	0.3	38.60		0.6	0.3
Gate conc	1.2	0.8	38.80	0.42	1.6	0.8
Tailing	91.3	59.7	27.17		84.0	41.5
Assay feed	-	-	32.45		-	-
Calc feed	100.0	65.4	29.52		100.0	49.4

*From Internal Report MS-AC-63-1206.

Jigging Tests on 3 m Products Crushed to 4 m

Due to the relatively poor grades and recoveries made in treating the 3 m "B" section ore, it was decided to combine all the gate concentrate and tailing products, crush them to minus 4 m, and rejig after thorough mixing. The amount to be rejigged was about 16 tons. A run of three days was made at a feed rate of 2,400 lb/hr. The size of ragging used was 3/8 in., in No. 1 and 4 Hutches, and 1/2 in. in No. 2 and 3 Hutches. Stroke was 3/8 in. at a speed of 155 rpm. During the whole test the gate concentrate was ground in a 20 in. by 30 in. rod mill with a charge of 500 lb of rods. After grinding, the gate concentrate was returned to the jig feed, and mixed with the crude feed by a classifier. Under steady conditions the rate of gate concentrate was maintained at an average of 1,500 lb/hr. The averaged results of the run are shown in Table 11.

TABLE 11

Results of Jigging 3 m Products Crushed to 4 m

Product	Weight %	Weight % of crude feed	Analysis %* Fe	Analysis %* P	Distn % Fe	Distn % as crude feed Fe
No. 1 Hutch	2.3	1.9	60.8	0.12	3.7	2.8
No. 2 Hutch	5.5	4.6	64.90	0.07	9.6	7.3
No. 3 Hutch	17.8	14.8	61.98	0.10	29.5	22.4
No. 4 Hutch	7.9	6.6	60.16	0.12	12.7	9.6
-65 m Hutch product	1.2	1.0	51.72		1.7	1.3
Gate concentrate	62.3	-	47.54		-	-
Rod mill discharge	62.5	-	47.96		-	-
Cone o'flow**	0.1	0.1	46.74		0.1	0.1
Class o'flow	1.9	1.6	39.86		2.1	1.6
Tailing	63.3	52.8	24.01		40.6	30.7
Assayed feed	-	-	37.18		-	-
Calc feed	100.0	83.4	37.3		100.0	75.8

*From Internal Report MS-AC-63-1244.
**Overflow from a cone holding No. 1 and 2 Hutch products.

Screen tests were done on various products shown in Table 11 and the results are shown in Table 12.

TABLE 12

Results of Screen Tests

Size	Jig feed	Gate concentrate	Rod mill discharge	Tailing Weight %	Tailing % Fe	Tailing Distn % Fe
+6 m	17.0	13.7	2.6	3.9	14.18	2.1
-6 +8 m	23.1	21.8	15.9	12.1	16.20	7.5
-8 +10 m	18.6	21.9	25.2	17.7	20.87	14.1
-10 +14 m	11.1	16.9	19.4	14.6	25.39	14.1
-14 +20 m	9.8	20.2	15.1	15.6	29.66	17.6
-20 +28 m	6.4	3.2	7.9	12.2	33.37	15.5
-28 +35 m	4.6	2.2	4.2	9.3	34.58	12.3
-35 +48 m	2.8	0.1	2.3	5.9	33.77	7.6
-48	6.6	-	7.4	8.7	27.97	9.2
Total	100.0	100.0	100.0	100.0	26.2	100.0

Jigging Tests on "C" Section

Tests on 4 m Feed

It was decided to do all the tests on "C" section ore crushed to minus 4 m. The first test was run at a feed rate of 3,200 lb/hr using a 3/8 in. stroke at a speed of 160 rpm. The size of ragging was 1/4 in. except for 3/8 in. in No. 1 Hutch. The results of this test are shown in Table 13. About 7 tons of feed were treated in this test.

TABLE 13

Results of Jigging 4 m Feed

Product	Weight %	Analysis %*		Distn %
		Fe	P	Fe
No. 1 Hutch	2.5	56.89	0.12	4.3
No. 2 Hutch	4.8	65.57	0.08	9.5
No. 3 Hutch	8.6	61.04	0.05	15.9
No. 4 Hutch	11.2	54.05	0.16	18.3
-65 m Hutch product	2.8	39.16		3.3
Gate concentrate	12.5	39.72	0.22	15.0
Cone o'flow	0.5	30.4		0.1
Tailing	57.1	19.42		33.6
Assay feed	-	31.84	0.19	-
Calc feed	100.0	33.03		100.0

*From Internal Report MS-AC-63-1223.

As a continuation of this test the gate concentrate was returned to the jig feed, without any grinding, at a rate of 600 lb/hr under steady operating conditions. Overall iron recovery in the four hutch products was 46.6% at a combined grade of 60.0% Fe. The feed assayed lower than expected but improved in subsequent tests. However, this accounted in part for the low iron recoveries.

Screen tests were done on various products and the results are shown in Table 14.

TABLE 14

Results of Screen Tests

Size	Jig Feed	No. 1 Hutch Product	No. 2 Hutch Product	No. 3 Hutch Product	No. 4 Hutch Product	Gate Concentrate	Tailing
+6m	14.8	-	33.3	3.9	13.0	43.7	12.2
-6+8m	23.2	0.4	29.4	34.0	29.2	39.9	23.5
-8+10m	17.1	0.8	11.9	25.5	32.0	13.0	19.7
-10+14m	10.3	1.3	3.2	11.3	16.4	2.7	11.8
-14+20m	8.4	4.5	2.6	7.0	7.5	0.5	10.5
-20+28m	5.8	10.0	2.6	2.9	1.4	0.2	7.5
-28+35m	4.4	15.7	3.2	1.5	0.2	-	6.7
-35+48m	3.3	16.3	13.8	13.9	0.3	-	4.1
-48m	12.7	51.0					4.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

A test was run with the same jig settings as before at a feed rate of 3,200 lb/hr. In this test an effort was made to increase the iron recovery without sacrificing the grade too much. The results are shown in Table 15. The amount of feed treated in this test was 7 tons.

TABLE 15

Further Results of Jigging 4m Feed

Product	Weight %	Analysis % *		Distn %
		Fe	S	Fe
No. 1 Hutch	1.5	62.46		2.6
No. 2 Hutch	4.9	65.29		8.8
No. 3 Hutch	9.1	63.50		16.0
No. 4 Hutch	11.6	57 27		18.4
-65 m Hutch Product	1.2	56.46		1.9
Gate Concentrate	18.2	42.72		21.5
Cone o'flow	0.1	43.14		0.1
Class. o'flow	2.0	32.75		1.8
Tailing	51.4	20.32		28.9
Assay feed	-	37.1	0.018	-
Calc. feed	100.0	36.0		100.0

* Internal Report MS-AC-63-1225

A final test was run on the last 8 tons of minus 4m 'C' ore in which the gate concentrate was ground in the rod mill as before and then returned to the feed end of the jig. The crude feed rate was set at 3,000 lb/hr and, after steady conditions had been reached, 1,200 lb/hr of ground gate concentrate was fed back for rejigging. The size of ragging used was 3/8 in. on No. 1 and 4 Hutches, and 1/2 in. on No. 2 and 3 Hutches. The stroke was 3/8 in. at a speed of 154 rpm. The results of the test are shown in Table 16.

TABLE 16

Results of Jigging With Return of Ground Gate Concentrate

Product	Weight %	Analysis % *				Distn %
		Fe	P	Tot. P	SiO_2	Fe
No. 1 Hutch	2.0	62.84	0.08		6.68	3.5
No. 2 Hutch	6.0	65.26	0.07	0.09	4.64	10.9
No. 3 Hutch	10.2	63.94	0.08	0.11	6.00	18.1
No. 4 Hutch	10.2	60.50	0.11		8.84	17.1
-65m Hutch product	1.1	59.14	0.10			1.8
Gate Concentrate	40.0	51.90				-
Rod Mill Discharge	-	52.25				-
Cone o'flow	0.1	40.77				0.1
Class. o'flow	5.3	32.90				4.8
Tailing	65.1	24.25				43.7
Assay feed	-	38.18	0.19			-
Calc feed	100.0	36.09				100.0

*From Internal Report MS-AC-63-1234

The results of screen tests on various products are shown in Table 17.

TABLE 17
Results of Screen Tests

Size	Gate Concentrate	Rod Mill Discharge	Tailing		Distn % Fe
			Weight %	Fe%	
+4m	0.4				
-4+6m	25.1	2.2	7.4	13.14	4.0
-6+8m	31.7	9.1	15.5	14.67	9.4
-8+10m	23.2	23.3	16.5	18.78	12.9
-10+14m	11.2	20.0	12.4	22.89	11.7
-14+20m	6.1	16.7	12.4	27.81	14.3
-20+28m	1.8	9.3	9.5	31.67	12.4
-28+35m	0.5	5.5	7.9	33.85	11.0
-35+48m		3.3	5.4	34.17	7.6
-48m	-	10.6	13.0	31.11	16.7
Total	100.0	100.0	100.0	24.19	100.0

Jigging Tests on Recombined Products

From some of the previous tests on "C" section ore, the No. 4 Hutch products and gate concentrate products assayed well below 60% Fe. A composite sample of about 4 tons was made up from these products and thoroughly mixed. The jig circuit used was the same as before with the gate concentrate being ground in the rod mill and then circulated back to the feed end of the jig. The rate of feed was 1,500 lb/hr, and the rate of ground gate concentrate being recycled was 600 lb/hr. The results of the test are shown in Table 18.

TABLE 18

Results of Rejigging Composite Products

Product	Weight %	Weight % of crude feed	Analysis %* Fe	Analysis %* P	Distn % Fe	Distn % as crude feed Fe
No. 1 Hutch	2.9	0.9	62.47	0.08	3.6	1.4
No. 2 Hutch	11.4	3.4	63.91	0.08	14.4	5.8
No. 3 Hutch	29.1	8.7	60.88	0.10	35.1	14.0
No. 4 Hutch	8.6	2.6	58.84	0.12	10.0	4.0
-65 m Hutch product	1.1	0.3	55.03		1.2	0.5
Gate concentrate	41.1	-	51.50		-	-
Rod mill discharge	-	-	52.04		-	-
Cone o'flow	0.1	-	46.59		0.1	-
Class o'flow	0.8	0.2	47.54		0.7	0.3
Tailing	46.0	13.7	38.38		34.9	13.9
Assay feed	-	-	50.70	0.18	-	-
Calc feed	100.0	29.8**	50.56		100.0	39.9*

*From Internal Report MS-AC-63-1272.
**From the results shown in Table 15.

In the above test the tailing product assayed high due largely to the high grade feed. This resulted in a higher than normal gravity bed which increased the loss of fine iron. The tailing product was therefore recombined and rejigged at a rate of 3,000 lb/hr. Water was added on all the hutches to try to reduce the suction. No gate concentrate was returned to the feed end of the jig. The results are shown in Table 19.

TABLE 19

Results of Rejigging Tailing Product

Product	Weight %	Weight % of crude feed	Analysis % Fe	Distn % Fe	Distn % as crude feed Fe
No. 1 Hutch	2.8	0.4	58.19	3.9	0.6
No. 2 Hutch	26.6	3.6	52.55	33.8	4.7
No. 3 Hutch	22.0	3.0	47.95	25.5	3.5
No. 4 Hutch	2.6	0.4	46.10	2.9	0.4
-65 m Hutch product	0.4	0.1	50.94	0.5	0.1
Class o'flow	0.2	-	40.30	0.2	-
Cone o'flow	-	-	48.76	-	-
Gate concentrate	17.8	2.4	32.00	13.8	1.9
Tailing	27.6	3.8	29.18	19.4	2.7
Assay feed	-	-	42.15	-	-
Calc. feed	100.0	13.7	41.2	100.0	13.9

The results of a screen analysis on the tailing product are shown in Table 20.

TABLE 20

Screen Analysis of Tailing Product

Size	Weight %	Analysis % Fe	Distn % Fe
+6 m	13.6	16.36	7.5
-6 +8 m	18.5	23.13	14.6
-8 +10 m	13.7	28.93	13.4
-10 +14 m	10.7	32.00	11.6
-14 +20 m	11.4	33.21	12.8
-20 +28 m	9.5	35.62	11.6
-28 +35 m	7.6	36.91	9.5
-35 +48 m	5.3	38.28	6.9
-48 m	9.7	36.67	12.1
Total	100.0	29.45	100.0

This test completed the work done on jigging.

Jig Water Consumption

The amount of water being used during jigging was measured and the averaged results from several runs are shown in Table 21.

TABLE 21

Water Consumption Used in Jigging

Sampling Point	Amount of Suction	GPM
No. 1 Hutch	3/4	6.3
No. 2 Hutch	Full	6.3
No. 3 Hutch	Full	7.2
No. 4 Hutch	-	8.4
Gate	-	7.2
Tailing	-	21.6
Total		57.0

Evaluation of Jig Concentrates

All the concentrate products from the tests were stored in drums and weighed. Composite samples of concentrate were made up from each section for further laboratory testing and analysis. From the results of weighing the feed samples during jigging it was estimated that the original shipment contained 8 tons of "A" section, 22 tons of "B" section, and 22 tons of "C" section excluding the unmarked bags and waste rock shipped inadvertently. The total weights of concentrate produced are shown in Table 21. For ease of handling, No. 1 and 2 Hutch products were combined and stored together. No screening was done on 65 m except on the composite samples that were made up for analysis.

TABLE 22

Summary of Jig Concentrate Products

Section	Product	Weight (lb)	Weight %	Analysis % (estimated) Fe	Analysis % (estimated) P	Distn % Fe	Distn % P
A	No. 1 and 2 Hutches	1409	3.6	62.3	0.20	3.6	5.6
	No. 3 Hutch	2748	7.0	60.5	0.25	6.9	13.6
	No. 4 Hutch	603	1.5	57.4	0.28	1.4	3.3
Sub-total		4760	12.1	60.7	0.24	11.9	22.5
B	No. 1 and 2 Hutches	6380	16.2	58.3*	0.14	15.2	17.7
	No. 4 Hutch	8343	21.2	62.5	0.12	21.4	19.8
	No. 4 Hutch	4768	12.2	62.0	0.13	12.2	12.4
	Gate concentrate	1653	4.2	61.5	0.13	4.2	4.3
Sub-total		21144	53.8	61.0	0.13	53.0	54.2
C	No. 1 and 2 Hutches	5549	14.1	63.1	0.09	14.4	9.9
	No. 3 Hutch	6052	15.4	62.2	0.08	16.2	9.5
	No. 4 Hutch	1809	4.6	60.5	0.11	4.5	3.9
Sub-total		13410	34.1	63.7	0.09	35.1	23.3
Grand total		39314	100.0	61.9	0.13	100.0	100.0

*This product contained a considerable amount of low grade fines (minus 65 m) assaying about 40% Fe which could be removed by screening or probably by cycloning.

It was calculated that the overall iron content of the shipment was 38.65%. The results of calculating the overall recovery, making allowances for spillage and the moisture content of the concentrate, are shown in Table 23.

TABLE 23

Calculation of Overall Recovery

Product	Weight (tons)	Weight %	Analysis %		Distn %	
			Fe	P	Fe	P
Jig concentrates	19.7	37.9	61.9	0.13	60.7	19.2
Tailings	32.3	62.1	24.5	0.34	39.3	80.8
Feed (calcd)	52	100.0	38.65	0.26	100.0	100.0

Overall ratio of concentration was 2.64:1.

DISCUSSION OF RESULTS

It was the purpose of the investigation to find out if the ore could be concentrated by jigging on equipment that could be upscaled so that comparable results could be obtained on existing commercial-size equipment.

The main gangue constituents of the ore were silica, in the form of jasper, and phosphorus, in the form of apatite. It was believed, before the tests started, that the apatite was intimately associated with the jasper, and the results tended to confirm this. As the grade of jig concentrate increased in iron content, the amount of phosphorus present decreased.

The jig was run under varying conditions. On each ore section tests were run to obtain the best iron recovery at reasonable grades followed by tests run under conditions to obtain the best grade of concentrate possible. Eventually a compromise was reached in which all the ore was upgraded to an average of about 62% Fe with 60% overall recovery. However the results showed that recoveries of about 70% could be obtained by lowering the overall grade to about 57% Fe with an increased silica and phosphorus content in the concentrates. Iron recovery was not as high as was obtained in the original laboratory jig tests. However the grade of feed to the laboratory jig was considerably higher and the feed contained a higher ratio of hematite to jasper as a result. A sample of final jig tailing was taken and the three main constituents, jasper, conglomerate, and hematite were picked out by hand and assayed. The results are shown in Table 24.

TABLE 24

Analysis of Jig Tailing Constituents

Product	Weight %	Analysis % Fe	Distn % Fe
Jasper	63	15.01	39.2
Hematite	26	51.66	55.7
Conglomerate	11	11.20	5.1
Feed	100	24.1	100.0

It can be seen from the results of this analysis that, as the jasper content of the jig feed increased, the recovery of hematite by jigging was bound to be lower when based on the amount of iron in the crude feed. However when the recovery of iron by jigging is calculated on the hematite content of the crude feed alone, the results are consistent for all the sections treated and approximate a hematite recovery of 75%. Most of the hematite that was lost in the jig tailing was either very fine or else in the form of flat particles which tended to skim across the surface of the jig bed and could not be drawn into the hutch products. The results of some heavy-liquid tests, done on some jig products from Table 16, are shown in the appendix.

When the tests were started it was originally thought that the crude ore would be first jigged, and the tailing product re-jigged to recover additional iron at a lower grade. For this reason the gate concentrate product was kept as close to a grade of 60% Fe as possible to avoid re-treatment. However, it was found that by running higher feed rates and increasing the amount of gate concentrate produced, most of the middling particles could be recirculated after a slight grind in a rod mill. This procedure reduced the operation to a single jigging stage, and, by increasing the specific gravity of the bed slightly with the return of middlings, appeared to produce higher grade hutch products. Further testing would be required to obtain the best rate of middling return and the best amount of grinding.

CONCLUSIONS

The results of this investigation showed that the Crest ore, as represented by the shipment treated, could be upgraded to concentrates containing better than 60% iron with a ratio of concentration of the order of 2.65:1. On some of the hutch products the iron grade was well over 64% iron with less than 6% silica and 0.10% phosphorus. However, it is doubtful if a sufficient quantity of concentrate to meet market specifications can be produced by jigging alone. Some further form of concentration is indicated and this will be the next stage of work at the Mines Branch.

Another method of gravity preconcentration that has been tried on a small scale is the use of heavy-media cyclones with a ferro-silicon or magnetite medium. Good rejection of the gangue is obtained up to a certain stage but it is doubtful if concentrate grades better than 58% iron can be obtained.

APPENDIX

Heavy liquid tests were done on three jig products from a mill run, the results of which were shown in Table 16. About 100 g of each sample was treated at densities from 2.80 to 3.70 with the results shown in Table 25.

TABLE 25

Results of Heavy Liquid Tests

Product	Gate concentrate			R.M. discharge			Tailing		
	% weight	% Fe	Distn % Fe	% weight	% Fe	Distn % Fe	% weight	% Fe	Distn % Fe
Float at 2.80	0.6	8.98	0.1	3.2	6.56	0.4	21.3	6.72	6.7
" " 2.90	0.4	9.71	0.1	2.7	9.75	0.5	15.6	9.84	7.3
" " 2.96	1.2	13.72	0.3	2.6	13.53	0.7	12.9	13.27	8.0
" " 3.10	2.6	17.97	0.9	6.2	16.35	2.1	19.2	17.64	16.0
" " 3.20	1.6	28.0	0.8	1.3	25.80	0.7	3.2	24.93	3.8
" " 3.70	15.5	37.71	10.6	29.6	42.08	25.5	17.4	35.21	28.8
Sink at 3.70	78.1	61.35	87.2	54.4	62.96	70.1	10.4	60.06	29.4
Feed*	100.0	54.9	100.0	100.0	48.9	100.0	100.0	21.2	100.0

*Calculated.